# Problem 2.51 (modified)

A tennis player throws a ball straight up. It leaves the hand 2 meters above the ground and takes 4.0 seconds to return to the same height.

a.) What is the ball's acceleration on the way up (include sign and units)?

b.) What is the ball's acceleration at the top of its flight?

c.) What is the ball's acceleration on the way down?

d.) What is the velocity of the ball when it reaches its maximum height?

e.) What is the initial velocity of the ball (include sign and units)?

f.) What is the ball's maximum height?

New set-up: The ball is again thrown up. At a particular point in time, it's velocity is registered at +12 m/s upward. If the stopwatch starts at that point:

g.) How fast is it moving after .3 seconds?

h.) How fast is it moving after it has traveled .2 meters?

i.) How long will it take to get to the point where it is moving at -4 m/s?

j.) Where will it be after the first .7 seconds?

A tennis player throws a ball straight up. It takes 4.0 seconds for the ball to return to the same height. (Many of these are THINK problems.)

a, b and c.) The acceleration of gravity is constant and, close the earth, is ALWAYS

$$a_{grav} = -9.8 \text{ m/s}^2$$

no matter what the body is physically doing.

d.) What is the velocity of the ball when it reaches its maximum height?

zero in the "y" direction

e.) What is the initial velocity of the ball (include sign and units)?

$$v_{max} = v_1 + a_{grav}(\Delta t)$$

$$\Rightarrow \quad -v_1 = (-9.8 \text{ m/s}^2)(2 \text{ sec})$$

$$\Rightarrow \quad v_1 = 19.6 \text{ m/s}$$

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f.) What is the ball's maximum height?

$$\left(\cancel{v_{max}}\right)^2 = (v_1)^2 + 2(a_{grav})(y_{max} - y_1) \quad (v_{max} = 0)$$

$$\Rightarrow \quad 0 = (19.6 \text{ m/s})^2 + 2(-9.8 \text{ m/s}^2)(y_{max} - 2)$$

$$\Rightarrow \quad y_{max} = 21.6 \text{ m}$$

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h.) How fast is it moving after it has traveled .2 meters?

i.) How long will it take to get to the point where it is moving at -4 m/s?

j.) How far will it travel in the first .7 seconds?

A tennis player throws a ball straight up. It takes 4.0 seconds for the ball to return to the same height. (Many of these are THINK problems.)

New set-up: The ball is again thrown up. At a particular point in time, it's velocity is registered at +12 m/s upward. If the stopwatch starts at that point:

g.) How fast is it moving after .3 seconds?

$$v_{.3} = v_0 + a_{grav}(\Delta t)$$
$$\Rightarrow \quad v_{.3} = (12 \text{ m/s}) + (-9.8 \text{ m/s}^2)(.3 \text{ sec})$$
$$\Rightarrow \quad v_{.3} = 9.06 \text{ m/s}$$

h.) How fast is it moving after it has traveled 4 meters?

$$(v_4)^2 = (v_o)^2 + 2(a_{grav})\Delta y$$
$$\Rightarrow \quad v_4 = (12 \text{ m/s})^2 + 2(-9.8 \text{ m/s}^2)(4 \text{ m})$$
$$\Rightarrow \quad v_4 = 8.1 \text{ m/s}$$

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New set-up: The ball is again thrown up. At a particular point in time, it's velocity is registered at +12 m/s upward. If the stopwatch starts at that point:

i.) How long will it take to get to the point where it is moving at -4 m/s?

$$v_4 = v_0 + a_{grav}(\Delta t)$$

$$\Rightarrow \quad (-4\ \text{m/s}) = (12\ \text{m/s}) + (-9.8\ \text{m/s}^2)t$$

$$\Rightarrow \quad t = 1.63\ \text{sec}$$

j.) How far will it travel in the first .7 seconds?

$$x_4 = x_o + v_0(\Delta t) + \left(\frac{1}{2}\right)a_{grav}(\Delta t)^2$$

$$\Rightarrow \quad \Delta x = (12\ \text{m/s})(.7\ \text{s}) + \left(\frac{1}{2}\right)(-9.8\ \text{m/s}^2)(.7\ \text{sec})^2$$

$$\Rightarrow \quad \Delta x = 6.0\ \text{m}$$